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# Notes on the Influence of Light on certain dorsiventral Organs.

BY KATHARINE CLEVELAND BURNETT.

(PLATE 297.)

The influence of light on morphology and anatomy of dorsi-ventral organs comprises a most important part of plant physiology. It is necessary therefore to explain that the work set forth in this paper is of a very limited character, owing to the short time available in a laboratory course, so that the subject should be limited to the study of the influence of light on the morphology and anatomy of dorsi-ventral organs of two plants studied during the months of March, April and May.

The influence of light on a plant may be negatively studied by watching its behavior when deprived of light. The results of this deprivation are morphological, anatomical and physiological, and are known as the phenomena of etiolation.

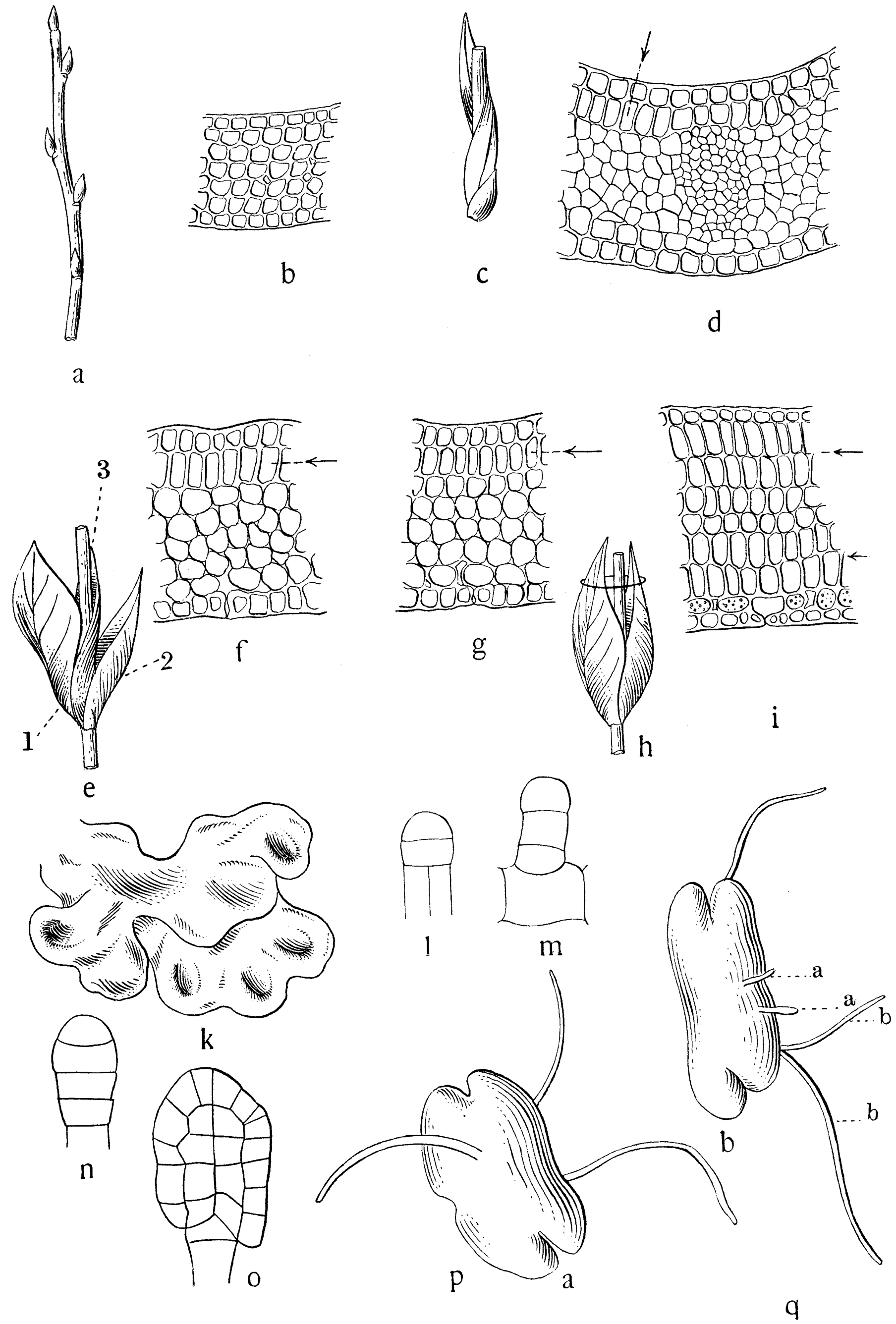
Some of these results are well known and prominent, many are exceptional and disputed.

As a general thing, we notice morphologically the lengthening of the internodes and the smallness of dorsi-ventral leaves; also, that the leaves make a very small angle with the stem.

Studied from an anatomical point of view, the vascular and thick-walled tissues are found to be much less developed in the internodes, and no differentiation of palisade and spongy tissue is found in the leaves; this is almost a physiological point, being connected with the non-formation of green chlorophyll pigment. A green plant deprived of light forms no green chlorophyll pigment and even loses that which it already has formed.

It has been stated by various authorities that a dorsi-ventral leaf owes its differentiation of palisade and spongy tissue entirely to the influence of light, and *that* for a distinct purpose. According to Vines,* "palisade layers occur always beneath the epidermis of those surfaces which are directly exposed to the sun's rays. If a plant be grown in the shade the palisade layers are imperfectly differentiated even if they can be detected at all. Development of palisade layers is clearly a peculiarity of leaves which are exposed to sunlight. Bright light promotes assimilation and oxida-

* Vines. A Students' Text-Book of Botany, 686–687.




INFLUENCE OF LIGHT ON DORSIVENTRAL ORGANS.

tion and decomposition of chlorophyll. Palisade tissue affords protection from the latter effect. When there is diffuse daylight the chlorophyll corpuscles are arranged horizontally along the upper surface of the cells. In direct sunlight they are vertical. The elongated form of the palisade tissue facilitates this withdrawal. The spongy tissue is especially adapted to transpiration, so in submerged water plants we find no palisade nor spongy tissue. First, the light is not intense. Second, they do not transpire."

Furthermore, MacDougal, in his *Experimental Plant Physiology*,* says that if young leaves of beech be turned so that the morphological under surface becomes the upper, the palisade will be found on what was originally the under surface.

The following investigations were made for the purpose of verifying these statements, and, furthermore, to see if the tissues of the leaf could be changed after the anatomical differentiation had taken place, that is, after the palisade tissue had formed could the leaf then be turned and palisade tissue be formed on the side now exposed to light.

The plant experimented with was the *Salix alba*. Young twigs were obtained April 17th with buds ½ cm. long, slightly swollen but still covered with scales, the leaves, therefore, were not exposed directly to the influence of sunlight (a).

On cross-sectioning a bud the tissue of the leaves showed regularly arranged parenchymatic tissue with no differentiation of palisade or spongy (b).

The twigs were put in water, some in the dark and some exposed to light, to see whether the willow showed any exceptions to the ordinary facts of the etiolation. Ten days later, April 27th, the willow grown in darkness showed well marked etiolation. The terminal bud had grown 3½ cm., being now 4 cm. long, the the lateral buds only from 1–2 cm. The internodes varied in length from ¼ cm. to 1 cm. The leaves were small, from ½ to ¾ cm. in length; they made a small angle with the stem and had no green chlorophyll pigment.

On cross-sectioning, the anatomy had changed but little from that of the bud studied ten days earlier. There was a very slight

* Pp. 73–74.

lengthening, vertically, of the first layer of cells under the epidermis of the upper surface, but no further differentiation, merely a growth in size and number of cells.

The bud grown in light had developed in six days (April 23) as follows: (c) The entire bud had lengthened, being now 1 1/4 cm.; all but one scale had fallen off. The outer, lower leaf was 3/4 cm. long and of a delicate green color, the leaves showed no sign of hyponasty, but were closely folded around the stem. The bud was then cross sectioned to see the anatomical changes, if such had occurred. The outer lower leaf showed a slight indication of palisade tissue by the lengthening of the first row of cells under the upper epidermis (d.) This surface had not been exposed to direct rays of light, the under surface directly exposed to light showed no sign of palisade tissue. These facts indicate that the formation of palisade tissue is the result of an inherent quality of the leaf, only assisted and not induced by light.

An inner, upper leaf of the bud, still enclosed by the outer leaves on the cross section, showed no differentiation of palisade and spongy tissue.

On April 27th, on examining the bud grown in light, we find a different morphology and far greater anatomical changes than in the etiolated bud grown the same length of time. The bud is 1 1/2 cm. long, the outer lower leaf 1 cm. long, large leaf and short internodes as opposed to small leaves and long internodes of the etiolated bud examined. This outer leaf forms a small angle with its stem for 3/4 of its length when its upper surface has grown very rapidly, so that the remaining 1/4 of the blade makes an angle of 90° with the stem, so that this part of the surface receives direct rays from the sun. This leaf is bright green. On examination by cross sectioning we see decided development; a well formed layer of palisade tissue under upper epidermis, spongy tissues on under surface, many stomata and large air spaces.

On April 30th, after two weeks' growth, the leaves are opening still further. The outer lower leaf, corresponding to the leaf studied, April 27th, makes an angle of 45°, half its length from the base and the rest of the way an angle of 90°. The second leaf just above is at an angle of 45° throughout its entire length. The other leaves are still folded about the stem. The anatomical

differences are slight. The lower leaf shows no change. The one above it (f) just showing hyponasty is forming palisade and spongy tissues, and corresponds in its anatomy to the outer leaf studied April 27th. The next leaf, still folded on the bud, (g) shows a layer of palisade tissue and a slight formation of spongy tissue.

To sum up: in all these cases examined, the leaves, whose upper surfaces were appressed against the stem and so had in no case been directly exposed to light, showed beginning of formation of palisade tissue. The under surface being at this same time exposed to direct rays of sunlight, formed no palisade tissue whatever. Therefore, the results of these observations show that the general statements made regarding change in form of tissues in young leaf do not always hold true, as the palisade tissue is already formed on morphological upper surface before it has been exposed to direct sunlight and before the leaf can be turned.

There remains now the second consideration, namely, to see if, after the leaf has been turned, the tissues can be changed.

Two methods for experimenting were adopted. In the first the bud was tied April 30th, so that the leaf could not turn its upper surface to the light (h). On May 6th, six days later, on cross sectioning this leaf, the upper surface showed two well formed layers of palisade tissue (i). On the morphological under surface exposed to light, two rows of palisade tissue were formed, but not directly under the epidermis, the layer immediately under the epidermis being ordinarily formed cells with intercellular spaces. Another leaf, grown normally, was examined the same day, May 6th, and was found to be typical, that is with two rows of palisade tissue on upper surface and very loose spongy tissue on under surface.

The second method adopted was to turn the leaf over on its petiole so that the morphological under surface becomes the upper, and fasten the leaf with a split match. Owing to the leaf having been disturbed at various times, the result was not very successful. On examination the morphological upper surface turned away from the light still showed two rows of palisade tissue, but the cells have intercellular spaces as though taking on the nature of spongy tissue. The under surface now exposed to light shows tissue with less indication of intercellular spaces, but the cells are

not lengthening in palisade form. This latter was not a fair test, as the plant had not been properly cared for. The results obtained in the tied leaf were more satisfactory, indicating that palisade tissue already formed could not be changed, but that the parenchymatic tissue of the under surface, if exposed to light for a long time, would take on the palisade characteristics for the protection of the leaf from too intense light.

The *Lunularia*, being a plant whose dorsi-ventrality is marked by its structural peculiarities, was next investigated.

It may be well to speak briefly of its normal structure.* Campbell describes it thus: "The thallus is made up largely of parenchyma. The dorsal part occupied by a single layer of definite air chambers opening at the surface by a single pore, seen from the surface they form a network. The thallus is fastened by unicellular rhizoids from the dorsal surface. One of the methods of asexual reproduction is by the so-called gemmae. These gemmae are produced in special receptacles upon the *dorsal* side of the thallus, and are crescent-shaped in *Lunularia.* These cups are specially developed air chambers, which open. The gemmae arise from the bottom as papillate hairs; one papilla projects, and a wall is formed, separating this projection from the surface of the cup; this outer cell is again divided by horizontal walls until four are formed. Each of these four primary cells is divided by a vertical wall, the young thallus being but one layer in thickness (k, l, m, n, o.), but later walls appear in the central cells parallel to the surface, so it is lenticular. As it grows older, two growing points are established and lie in a depression so the older gemma is fiddle-shaped. The gemma is vertical, therefore has no distinction of dorsum and ventrum. The further development depends upon light. Whichever side touches the ground develops rhizoids; as soon as it becomes fastened to the ground the dorsi-ventrality is established."† Sachs says: "Certain cells on both convex sides are destined, according to circumstances, to grow out into root hairs; if both surfaces are equally illuminated, those grow which are able to follow influence of gravity. Zimmerman says influence of light is stronger, as if lower surface is illuminated

* Mosses and Ferns, 45–46.

† Physiology of Plants, 526.

the roots of shaded side develop." Pfeffer suggested it was partly due to action of gravity and effect of contact with substratum, but chiefly to influence of light.

The *Lunularia* (k, l, m, n, o.) in the laboratory had well developed gemmae cups ¼ cm. in the long diameter, in which were gemmae in all stages of development, from four-celled up to detached gemmae of plates of several layers. These last were the characteristic fiddle shape and were .45 to .5 mm. in size. Several dozens of these tiny gemmae were planted in moist earth March 2d. Three days later (March 5th), tiny rhizoids .1 mm. long had grown on surface touching the earth, the gemmae had grown to .97 by 0.5 mm. in length and breadth.

Several were then *turned* so that the upper side now became the side touching the earth, and allowed to grow four days, from March 5th to 9th. On examination long rhizoids 1 to 1.05 mm. in length had grown on what had been the upper surface, so we had the curious phenomenon of a gemmae with rhizoids on both surfaces. (p.a. q.b.)

We next tried to find at what stage of development the anatomical characteristics become permanent, so that no change can be induced by change in position.

Gemmae grown six days and having formed long rhizoids from 1 to 2 mm., on being turned, did not develop rhizoids on the dorsal surface.

Full grown thallus, with tips turned, produced no result, so that the conclusion here is that, though dorsi-ventrality can be induced by light and other accessory assistants, yet, after a certain development of the thallus, and that early in its history, the dorsi-ventrality becomes permanent and turning produces no change.

### Explanation of Plate 297.

a. Young twig of willow, buds still covered with scales, × ¾.

b. Cross section of a leaf from one of the buds, × 90.

c. Bud with leaves still folded, × 1½.

d. Section of outside leaf showing first indication of palisade tissue, circa × 190.

e. Bud unfolding showing leaves 1, 2, 3, × 1½.

f. Cross section of leaf 2, showing palisade tissue, circa × 190.

g. Cross section of leaf 3, showing palisade tissue, circa × 190.

h. Leaf tied so under surface is exposed to light, × 1½.

i. Cross section showing palisade tissue on both under and upper surfaces, circa × 190.

k. Thallus of *Lunularia* with gemmae cups, $\times$ 2¼.

l, m, n, o. Stages in development of gemmae, circa $\times$ 50.

p. a.<br>q. b. Gemmae with rhizoids aa. bb. grown on both ends, circa $\times$ 30.

## A new fossil Grass from Staten Island.

BY ARTHUR HOLLICK.

(PLATE 298.)

PHRAGMITES AQUEHONGENSIS n. sp.

Culms round, narrowly striate longitudinally, articulate, occasionally dotted with one or more circular scars immediately above the articulations; internodes short; rhizomes tuberous, branching, consisting of irregularly rounded, articulated parts, which are longer than broad, with knots or scars either at the joints or between them; leaves wanting.

Locality: Clifton, Staten Island, N. Y.

The first discovery of specimens representing this species was made in 1894, but these merely consisted of a few fragments of jointed stems and I referred them at the time to *Equisetum*.*

Subsequently better specimens were obtained, consisting not only of jointed stems, but also of tuberous rhizomes, and their affinity with the monocotyledons was then satisfactorily established.†

The generic name *Phragmites* has been finally adopted largely for the reason that similar fossil fragmentary remains have been described and figured under that genus, and not necessarily because our specimens are supposed to belong in it without question, although they certainly represent some grass. The specific name is coined from "Aquehonga," the Indian name for Staten Island.

The specimens figured are fairly representative of the material collected. They consist of fragments of culms and rhizomes, preserved in a conglomerate of yellow gravel, cemented with limonite.

This conglomerate is not in place where found, but forms part of the drift material, beneath the bowlder till, on the extreme southern edge of the terminal moraine. It was uncovered by reason of an excavation having been made there for building sand

* Proc. Nat. Sci. Assn. Staten Isld. 4: 37.

† Ibid. 6: 12.